

## **HIGH FREQUENCY ACOUSTIC RESPONSE CHARACTERIZATION AND ANALYSIS OF THE DEEP THROTTLING COMMON EXTENSIBLE CRYOGENIC ENGINE**

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### **ABSTRACT**

The Common Extensive Cryogenic Engine program demonstrated the operation of a deep throttling engine design. The program, spanning five years from August 2005 to July 2010, funded testing through four separate engine demonstration test series. Along with successful completion of multiple objectives, a discrete response of approximately 4000 Hz was discovered and explored throughout the program. The typical low-amplitude acoustic response was evident in the chamber measurement through almost every operating condition; however, at certain off-nominal operating conditions, the response became discrete with higher amplitude. This paper summarizes the data reduction, characterization, and analysis of the 4,000 Hz response for the entire program duration, using the large amount of data collected. Upon first encountering the response, new objectives and instrumentation were incorporated in future test series to specifically collect 4,000 Hz data. The 4,000 Hz response was identified as being related to the first tangential acoustic mode by means of frequency estimation and spatial decomposition. The latter approach showed that the effective node line of the mode was aligned with the manifold propellant inlets with standing waves and quasi-standing waves present at various times. Contour maps that contain instantaneous frequency and amplitude trackings of the response were generated as a significant improvement to historical manual approaches of data reduction presentation. Signal analysis and dynamic data reduction also uncovered several other features of the response including a stable limit cycle, the progressive engagement of subsequent harmonics, the U-shaped time history, an intermittent response near the test-based neutral stability region, other acoustic modes, and indications of modulation with a separate subsynchronous response. Although no engine damage related to the acoustic mode was noted, the peak-to-peak fluctuating pressure amplitude achieved 12.1% of the mean chamber pressure at its highest. The identification of this response in terms of an instability is also discussed.